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Linking Environmental Sustainability and Financial Resilience through the Environmental Footprints and Their Determinants: A Panel Data Approach for G7 Countries

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Abstract: The pursuit of sustainable development has received much attention recently as nations confront increasing environmental, social, and economic difficulties. In order to comprehend sustainable development's many facets and provide a plan for achieving them, this study conducts a thorough analysis of the concept. The study's dependent variable, environmental footprint, is based on a research model. On the other hand, financial inclusion, human capital development, green growth, technological innovation, and renewable energy are the independent factors. This study used secondary data collected between 1990 and 2022. To better capture the variable indicators, the index for green growth is constructed using the entropy-weighted technique. The panel dataset problem was resolved by using diagnostic tests, which include cointegration, correlation, cross-sectional dependence, variance inflation factor (VIF), and stationarity tests. The findings of the diagnostic test indicated that a fully modified ordinary least square would be the best approach to use with this panel. According to the findings, the long-term variance is 55%. Renewable energy, green growth, and technological innovation have a substantial negative link with financial risk, while greenhouse gas emissions, financial inclusion, and human capital development have a significant and positive relationship. Environmental sustainability may benefit from policies that the government creates and funds for sustainable development. The findings imply that the government should provide incentives in terms of financial resilience to technological innovations and natural resources so that they would switch to green sources and help to improve the quality of the environment that would be sustainable.

Keywords: financial resilience; green growth; financial risk; green innovations; natural resources; environmental sustainability; G7 countries

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1. Introduction

Global warming is the biggest issue facing humanity in the 20th century. The "climate system" is defined by the United Nations Framework on environmental degradation as "the entirety of the atmosphere, hydrosphere, biosphere, and geosphere and their interactions". Many studies have shown that environmental deterioration has negative effects on human health as well as societal stability and appropriateness. These effects include rising sea levels, temperature increases, weather severity, poor productivity, agricultural levels, and ecological deterioration [1,2].

Due to this increasing environmental degradation, there is the need of the time to focus on the development that is sustainable. The definition of environmental sustainability is mentioned in the study by [3], which is as follows: Development that satisfies current demands without jeopardizing the capacity of future generations to satisfy their own needs.

Typically, sustainability is defined as the meeting point of three pillars: the environment, or "Planet", society, or "People", and the economy, or "Profit or Prosperity".

At the close of the 20th century, [4] established the concept of the ecological footprint (EF). The aim of this study is to determine the extent to which people need the planet's regeneration potential in order to generate resources and ecological services. The biological productivity, or biocapacity, is compared to EF. Approximately 1.5 Earths are now needed by mankind to support its consumption [5]. It states that many environmentalists believe that Earth can only support a maximum of 4×10^9 people. EF is a commonly used metric to gauge the sustainability of the environment. It is a gauge of the amount of bioproductive land and water that is accessible on Earth as well as the portion that has been set aside for human use [6]. It is particularly helpful in increasing awareness of the environmental loads that humans place on the environment [7]. There is a huge environmental risk due to the substantial rise in CO_2 and other greenhouse gas emissions caused by the rapid population increase, globalization, and economic expansion. The environment is declining due to a number of important causes, including income, urbanization, deforestation, global trade, industrialization, population expansion, and energy use. Unfortunately, greenhouse gas emissions are frequently neglected for financial reasons. Due to this neglect, the greenhouse effect has intensified and is now causing a number of environmental and socioeconomic problems that have the potential to completely destroy human society. These problems include melting glaciers, deserts, and increasing sea levels. The United Nations states that switching to renewable energy is the best way to cut carbon dioxide emissions.

There are often sudden, unexpected changes in society that we have little control over. Both the survival of enterprises and global growth and development depend on innovation. But innovation and technology often depend heavily on the usage of fossil fuels, which came before rising atmospheric CO_2 and other forms of pollution [8]. Fossil fuel consumption has increased greenhouse gas (GHG) emissions since the Industrial Revolution, resulting in a serious danger to the environment. Global warming was primarily fueled by an increase in CO_2 emissions from 27,824.8 Mt to 37,596.9 Mt between 2003 and 2022, a 35.89% rise. The increasing greenhouse effect leads to problems such as increasing sea levels, desertification, and glacier melting, which might have disastrous effects on the history of society [9,10].

The environment is deteriorating, and climate change is the cause of these greenhouse gases, or GHGs. In an effort to promote economic growth, industrialization has resulted in a number of social, environmental, and climate change issues. The environment and the ability of living things to survive are negatively impacted by climate change. According to recent research, the Earth's surface warmed by 1.09 °C between 2011 and 2020 compared to 1850 and 1900. Over the next 20 years, the average temperature will rise by 1.50 °C due to global warming. The worldwide reach of these detrimental impacts of climate change is the same [11,12].

To protect a desired standard of living, it is imperative to significantly reduce carbon emissions and greenhouse gases during manufacturing in order to address the urgent environmental dangers. Global development strategies and concerns for equitable health are closely linked to the health effects of climate change. The people who have contributed the least to the problem and have the least access to resources are the ones who suffer the most from it. The world's poorest countries should accelerate their development and meet the MDG objectives as a result of climate change. It also emphasizes intergenerational justice. Inaction will exacerbate health inequalities by negatively affecting vulnerable communities' socioeconomic status. A sad legacy of our time will be the imbalance in which the wealthy cause the problem, and the disadvantaged bear the brunt of the repercussions [13].

Green growth is a socially and environmentally conscious approach to economic development that promotes social, environmental, and economic sustainability. It is an example of the "triple bottom line" concept in action. This paper makes the claim that green growth is essential to maintaining financial stability via the prism of growth-oriented finance theory. It acknowledges social inequality and environmental dangers as important components of economic growth. To this end, green growth functions as a corporate strategy. Additionally, it puts economic advancement first by focusing public and private expenditures on improved sustainable working practices [14,15].

The objective of the study is to advance the understanding of the complex interactions among environmental footprints, financial risk, renewable energy usage, financial inclusion, natural resources, and human capital development under financial resilience in G7 countries. The results of this study will give decision-makers important direction on how to set up effective green finance systems and distribute funding for environmental footprint, which is the fundamental part of sustainable development initiatives. Our research underscores the need to incorporate sustainable practices into economic progress, going beyond traditional methods of growth. We argue that green growth, defined by environmentally friendly practices and innovations, may produce superior environmental results. By examining the relationship between green growth and financial stability, we hope to obtain insight into their beneficial effects on environmental quality.

In addition, our research takes a comprehensive approach, including a range of economic aspects that have an impact on the environment, such as resource efficiency, the use of sustainable production and consumption practices, pollution control techniques, and renewable energy. Our objective is to determine practical methods for improving environmental quality by examining these components in conjunction with environmental footprint, green growth, and financial stability.

2. Literature Review

Footprints originating from the extraction of resources, manufacturing, consumption, maintenance, recycling, and/or disposal of materials, including all transit and distribution phases, are connected to the complete supply chain/network (burdening impacts). In most circumstances, in addition to burdening consequences, there are also unburdening impacts. Examples of these include using dangerous things instead of discarding them and replacing harmful systems with benign ones. Certain footprints may even turn negative as a result of burdening impacts increasing footprints while unburdening effects decrease them. Total footprints are the sum of the footprints that contribute to the burdening and unburdening of the ecosystem. In Figure 1, the idea of complete impacts is displayed.

The whole life cycle and all impacts must be considered in order to transition to more sustainable processes, goods, or activities [16]. Typically, only environmental burdens are quantified [17]. Nonetheless, a more comprehensive perspective needs to encompass any potential relieving impacts of a task [18]. The combined impacts of burdening and unburdening are known as total effects [19].

According to [20], environmental footprints should be determined using a life cycle approach that takes into consideration a system's whole life cycle. The life cycle of a system includes resource extraction and processing, production, use, and maintenance, as well as recycling or disposal, which includes all phases related to distribution and transportation [21]. Strict boundary selection is necessary to prevent problem-shifting or inadequate sustainability assessment. "Cradle-to-grave" and "cradle-to-cradle" are the ideal scenarios. From resource extraction (the "cradle") to disposal (the "grave"), the "cradle-to-cradle" option depicts the flow of materials. The "cradle-to-cradle" system demonstrates cyclical design from resource extraction (the "cradle") to recycling and/or reuse (the "cradle"). The "cradle-to-cradle" systems choose to use all of the trash, making them waste-free systems.

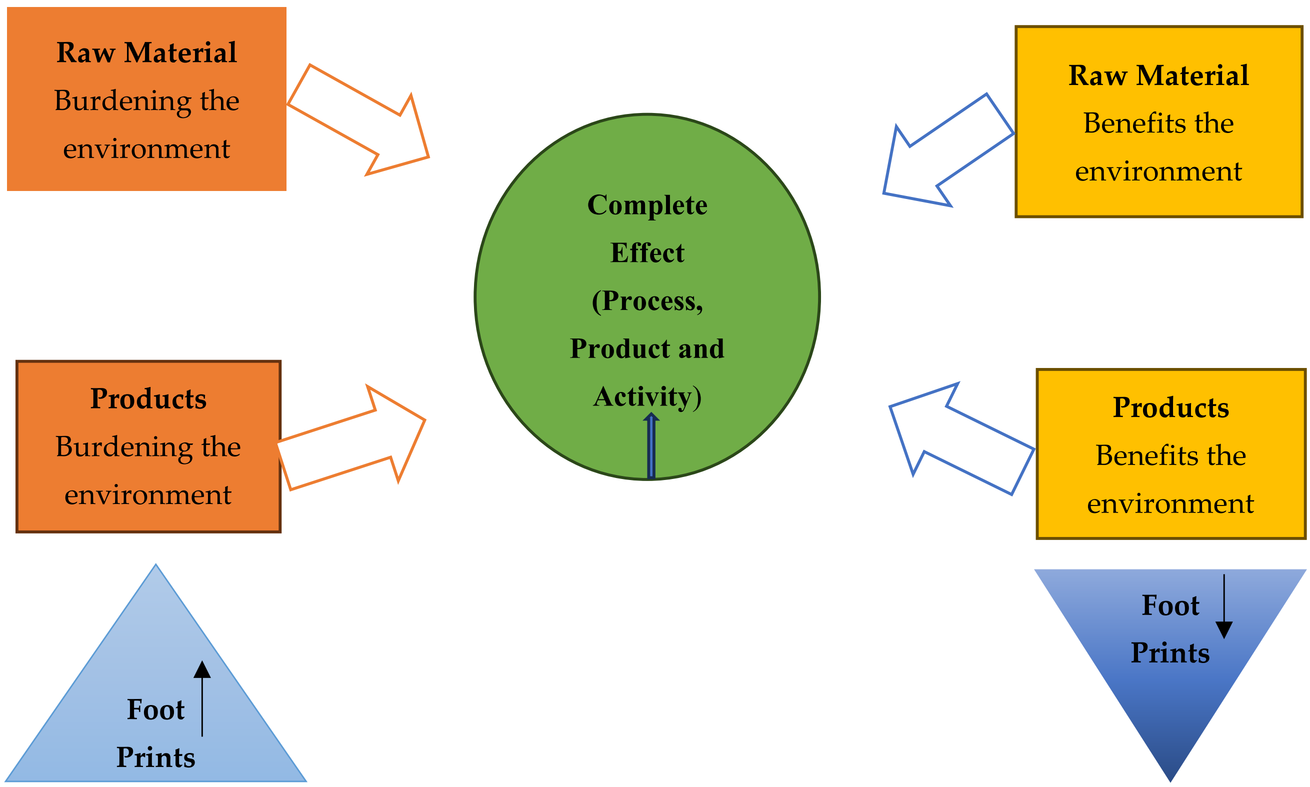

Figure 1. Representation of burdening, unburdening, and total effects [22].

Global warming has emerged as a significant worldwide concern [23]. More often than not, temperatures on the surface of the Earth and in the surrounding air are rising to greater and more intensely heated [24]. Greenhouse gas emissions (GHGs) are the main contributors to air pollution and global warming. There is a more noticeable negative impact on environmental quality with rising conveyance volumes. Among these consequences is the issue of air pollution brought on by burning fossil fuels, farming practices, emissions from factories and other industries, and other activities [25]. Many human activities release them into the atmosphere, including industrial and transportation processes [26].

Another study by [27] evaluated the impact of government programs and technology on greenhouse gas emissions in a small sample of economies in Asia and Africa. They found that countries have paid more attention to their policies for achieving the SDGs and sustainability. Scholars have assessed the consequences of a focused strategy for state policy since the SDGs were introduced, and they have proposed several policy implications for reaching all SDGs through the best possible use of state resources.

Rising sea levels, altered rainfall distribution, and intensified storms are among the anticipated and observed consequences of global climate change [28]. There are two main categories of current global warming strategies: (1) cutting back on the burning of fossil fuels and other greenhouse gas releases and (2) improving the sequestration of carbon. Nonetheless, several writers have also pointed out that a key factor in defining sustainable growth is financial vulnerability.

Theoretically, financial instability can lower environmental quality by creating an information asymmetry that makes it harder for financial institutions to support renewable energy initiatives. Similar to how financial sector instability affects FDI flows, it also hinders the economy's capacity to adopt environmental advances, which lowers the quality of the environment. Examine the many aspects of financial risk and the ways in which it affects individuals, markets, governments, and enterprises. Economic growth depends on financial stability, which also affects the quality of the environment. First, increased FDI might lead to faster economic development and higher energy consumption in the event of a safer financial climate bolstered by strong financial institutions.

An investigation of panel data encompassing Asian Pacific Economic Corporation (APEC) countries between 1990 to 2016 found that financial development significantly lowers both long- and short-term carbon emissions [29]. In the meanwhile, China's economic development and CO_2 emissions continue to be negatively correlated, according to Umar's research [30]. According to Mberak's testimony, financial development has a long-term negative impact on carbon emissions, demonstrating how economic progress lessens environmental harm [31].

The results of earlier research supported those [32] indicate a negative correlation between carbon dioxide emissions and financial risk. However, additional research revealed that F.R. increased CO_2 emissions. One such piece of research is conducted by [33] Human existence is at risk due to these pollutants. Hence, reducing carbon emissions is of utmost importance in order to avert global natural disasters [34].

Green growth, in contrast to sustainability, accelerates environmentally sustainable growth without slowing down the pace of fiscal expansion. Because of this, green growth is recognized as a path toward sustainable development and a workable low-carbon framework. Multi-sectoral activities are necessary to amass new resources via investment and innovation while promoting economic growth since green growth encompasses both short-term economic growth and long-term environmental sustainability [35,36].

China's economic growth is also aided by advances in technology, a rise in the financial risk index, and craftsmanship. We also learn that a country's economic success may be strongly impacted by investment and advances in technical innovation. Lastly, we find that China's economic success and financial risk are negatively correlated [37]. The findings support the high level of confidence in long-term projections of environmental discoveries and patents by demonstrating how environment-related technology supports green growth in the BRICS countries. As financial globalization advances, green growth in the BRICS countries is anticipated to increase [38].

The increasing rate of industrialization worldwide and the overuse of non-renewable energy sources are directly responsible for an increase in global temperature and a host of negative environmental circumstances. Furthermore, it is projected that global greenhouse gas emissions will rise by 50% by 2050, mostly as a result of CO_2 emissions from non-renewable energy resources [39]—the impact of technical progress on economic expansion. A study found a correlation between economic growth and the volume and caliber of creative activity [40].

Financial inclusion is necessary to achieve the sustainable development goals of the UN [41]. Numerous studies have examined various aspects of financial inclusion, such as its contribution to growth [41] its effect on financial solidity [42], its relationship to economic growth and national procedures in this field [43]. It is generally acknowledged that one effective way to address study budgets is to make financial services more accessible to the impoverished [44]. However, as noted that the majority of the data pertaining to the relationship between growth and financial inclusion are found at the micro and individual levels. The relationship between financial inclusion and overall economic development is still not well understood. It is conceivable to demonstrate a link, at least conceptually, between inequality, macroeconomic progress, and financial inclusion. The World Bank notes that there is some gray area in this association. The evidence indicates that capacity, not parental income, determines an individual's propensity for entrepreneurship.

The topic of financial inclusion has received much attention lately. For a variety of causes, scholars and policymakers have highlighted financial inclusion [45]. Consequently, involvement in finance reduces environmental deterioration. Investing in renewable energy sources may enhance the environment; a well-developed financial sector leads to lower financing costs, more efficient procurement procedures, and less pollution from oil. Nonetheless, a framework for integrated development policies has to be established to enhance local governments' transparency and accountability, particularly those that are heavily dependent on natural resources, in order to stop rent-seeking and the ensuing environmental damage. Economic actors should have access to financial services focused on green growth in order to enhance environmental quality and promote low-carbon and energy-efficient development, as outlined in the Sustainable Development Goals (SDGs) [46].

It is crucial to look at the connection between energy saving and broadband internet access. In order to support the expansion of the digital economy, high-speed broadband is seen as a strategic asset and is essential to the information and communication technology (ICT) infrastructure [47]. We may obtain a deeper understanding of the relationship between digital transformation, environmental sustainability, and financial stability by examining the effects of broadband infrastructure on financial stability. This will help to clarify the complex dynamics that are present in the digital era.

We may obtain a deeper understanding of the relationship between digital transformation, environmental sustainability, and financial stability by examining the effects of broadband infrastructure on financial stability. This will help us to better comprehend the complex dynamics that are present in the digital age.

3. Model and Methodology

This research addresses global concerns about climate change and considers the entire planet as its population. Because comprehensive and dependable statistics were readily available, a sample of seven countries—the United States, the United Kingdom, Japan, Germany, France, Italy, and Canada—was chosen to represent the G7 as a whole. Credible sources such as the OECD and the World Bank add to the validity of this study. This analysis period, which spans 32 years from 1990 to 2022, provides reliable and thorough data on important factors.

Acknowledging the limits of the data, the study concentrates on countries where statistics are accessible in an effort to offer relevant insights into world population patterns. This study examines how technological innovation, financial inclusion, green growth, renewable energy, soft infrastructure, and financial risk interact and affect sustainable development. Additionally, it looks at the relationship between green growth, renewable energy, soft infrastructure, sustainable development, technological innovation, financial inclusion, and greenhouse gas emissions. This study uses quantitative methods and secondary data, and it employs an approach that is similar to that of [48]. In order to properly describe the variables, the entropy-weighted method (EWM) was employed to generate the green growth index.

3.1. Entropy Weighted Method

Assigning an entropy weight to every parameter is the initial step. In order to obtain the entropy estimate, we must ascertain the number of samples (I = 1, 2, 3, . . . , *s*). For every sample, parameters *j* are assigned a score between 1 and *t*.

Therefore, Equation (1) may be used to construct the Eigenvalue matrix Z:

$$Z = \begin{matrix} Z_{11} & Z_{12} & \ldots & Z_{1t} \\ Z_{21} & Z_{22} & \ldots & Z_{2t} \\ . & . & \ldots & . \\ . & . & \ldots & . \\ . & . & \ldots & . \\ Z_{s1} & Z_{s2} & \ldots & Z_{st} \end{matrix} \tag{1}$$

Classifications include cost, interval, fixed, and efficiency feature indices. The normalizing building function X_{ij} for efficiency types is given by Equation (2):

$$X_{ij} = \frac{z_{ij} - z_{ij_{min}}}{z_{ij_{max}} - z_{ij_{min}}} \tag{2}$$

Regarding a parameter (j) inside a certain sample (i), the normalizing construction function is denoted by X_{ij}. Each index's minimum and maximum are represented by $z_{ij_{min}}$ and $z_{ij_{max}}$.

According to Equation (3), maximums are found in the original data from the quality analysis. To eliminate the inaccuracy brought up by the original matrix has to be modified before the weights are calculated caused by different measurements and units. Following transformation, the standard grade matrix X can be obtained.

$$\mathrm{X} = \begin{matrix} X_{11} & X_{12} & \ldots & X_{1t} \\ X_{21} & X_{22} & \ldots & X_{2t} \\ . & . & \ldots & . \\ . & . & \ldots & . \\ . & . & \ldots & . \\ X_{s1} & X_{s2} & \ldots & X_{st} \end{matrix} \tag{3}$$

The standard deviation of the Ith index in the Jth sample is represented by Q_{ij}, and it is computed as follows:

$$Q_{ij} = \frac{x_{ij}}{\sum_i^s x_{ij}} \tag{4}$$

The sum here presents the total sample. The entropy value Ei of the Ith index in the *EWM* is defined as

$$EWM_j = \left(\frac{1}{lnS}\right) \times \sum_{i=1}^{s} lnQ_{ij} \times Q_{ij} \tag{5}$$

For ease of computation, $Q_{ij} = 0$ is usually set when $Q_{ij} = 0$ in the *EWM* assessment. Entropy values (*EWM*) fall between 0 and 1. More data may be recovered, and the index i's degree of differentiation increases with increasing *EWMi*. The index should thus be given greater weight. Consequently, weight w_i in the entropy-weighted method (*EWM*) is calculated using the following method [49,50]

$$W_i = \frac{(1 - EWM_j)}{\sum_{j=1}^{t}(1 - EWM_j)} \tag{6}$$

Data from the World Bank and OECD was collected by following the studies of [51,52] that computed the green growth index using the cast-off entropy-weighted approach.

3.2. Model Construction

The Table 1 shows the variable description and data sources of the selected variables for this study. The basic framework of this study serves as its overall theoretical foundation. It is a system of links between the variables that have been logically constructed, recorded, and expanded and that have been identified through methods such as surveys of the literature, interviews, and observation that have been judged to be relevant to the issue situation.

$$EFP_{it} = \beta_0 + \beta_1 GG_{it} + \beta_2 FR_{it} + \beta_3 TNRR_{it} + \beta_4 TI_{it} + \beta_5 FI_{it} + \beta_6 HCD_{it} + \beta_7 URB_{it} + \beta_8 IND_{it} + \varepsilon_{it} \tag{7}$$

where EFP_{it} is Environmental Footprints, GG_{it} is used for Green Growth, FR_{it} denotes Financial Risk, $TNRR_{it}$ is referred to as Total Natural Resource Rent, TI_{it} is Technological Innovation, FI_{it} represents Financial Inclusion, HCD_{it} is used for Human Capital Development, URB_{it} presents Urbanization, IND_{it} is used for Industrialization and ε_{it} is used for standard error term.

Table 1. Variable description.

S. No	Variables	Notation	Indicators	Source Link	Literature
1	Environmental Footprints	EFP	Ecological Footprint	https://databank.worldbank.org/source/world-development-indicators	[53]
2	Green Growth	GG	GDP, Nitrous oxide emissions in the energy sector (% of total), CO_2, PM2.5 pollution, population exposed to levels exceeding WHO Interim Target-1 value (% of total), Industrial waste Resource consumption, Solid waste emissions	https://databank.worldbank.org/source/world-development-indicators	[54]
3	Financial Risk	FR	Total debt service (% of exports of goods, services, and primary income)	https://databank.worldbank.org/source/world-development-indicators	[55]
4	Technological Innovation	TI	Medium and high-tech exports (% manufactured exports)	https://databank.worldbank.org/source/world-development-indicators	[56]
6	Financial Inclusion	FI	Automated teller machines (ATMs) (per 100,000 adults)	https://databank.worldbank.org/source/world-development-indicators	[57]
7	Urbanization	URB	Urban Population	https://databank.worldbank.org/source/world-development-indicators	[58]
8	Industrialization	IND	Industry (including construction), value added (annual % growth)	https://databank.worldbank.org/source/world-development-indicators	[59]
9	Human Capital Development	HCD	Human Development Index	https://hdr.undp.org/data-center	[60]

Links accessed on 19 August 2024.

This model, which considers the effects of green growth, financial inclusion, natural resources, human capital development, and technological innovations, demonstrates the relationship between environmental footprints and financial risk. The control variables in the model are industrialization and urbanization. Here, "t" stands for periods, while "i" stands for individual nations.

4. Results and Discussion

4.1. Descriptive Analysis

For each individual variable presented in Table 2, there were 231 observations covering the G7 nations' time span from 1990 to 2022. The dataset's descriptive statistics provide the variables' data's range, mean, and median. In light of the descriptive statistics' findings, the environmental footprint has a mean estimate of 6.732, a range of 9.951, and an S.D. of 2.321. The financial risk descriptive statistic shows a mean of 15.341, a range of 95.947, and a standard deviation of 12.006. Green growth data display a range of approximately 0.01357, with an average in terms of mean of 0.634 and S.D. of 0.023.

Total natural resource rent has a mean value of 3.356, a range of 4.427, and a divergence value of 2.031 from the norm, according to the descriptive statistics. For technical innovation, the dataset shows an average value of 4.234 with a range of 6.464 and an S.D. of 0.823. The standard deviation is 0.006, the range is 5.827, and the mean value is 3.045, according to the descriptive financial inclusion data.

Table 2. Descriptive statistics.

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
EFP	231	6.732	1.321	7.981	17.932
GG	231	0.634	0.023	0.030	0.0024
FR	231	15.341	12.003	5.003	99.934
TNRR	231	3.356	2.301	3.896	7.006
TI	231	3.234	0.823	0.097	5.561
FI	231	3.045	0.006	0.004	5.831
HCD	231	3.45	4.281	5.081	3.921
URB	231	3.156	3.931	2.451	5.321
IND	231	5.654	2.312	3.245	6.892

4.2. Correlation Matrix

The correlation matrix in Table 3, unequivocally demonstrates that, at p = 0.01, there are significant positive correlations between financial risk, technological innovation, and environmental footprint (EFP) (3.41 *, 2.83 *, and 2.34 *). This shows that these factors and environmental footprint have a strong association. Put another way, there will be a relationship between growing environmental impact and financial inclusion as well as technological advancement.

Table 3. Correlation matrix.

	VIF	*EFP*	*GG*	*FR*	*TNRR*	*TI*	*FI*	*HCD*	*URB*	*IND*
EFP	2.03	1								
GG	1.24	−1.23 *	1							
FR	1.25	2.34 *	1.522	1						
TNRR	1.29	−1.62 *	0.05	1.03	1					
TI	1.25	3.41 *	0.82	−1.92 *	2.45 *	1				
FI	2.56	−2.83 *	1.03	2.43	1.43	3.21 *	1			
HCD	2.02	−0.34 *	2.31	1.45	3.25	3.21	2.03	1		
URB	2.21	−3.21 *	2.02	3.12	0.93	0.43	0.32	0.92	1	
IND	2.13	0.42	0.82	0.52	0.82	1.91	2.81	0.97	1.23	1

"*" represents the level of significance at 10 percent.

The correlation matrix indicates that there is a substantial negative association (−1.62 *, −1.92 *, −1.23 *, p = 0.01) between environmental footprints (EFP), financial risk (FR), total natural resource rent (TNRR), and green growth. This suggests that as financial risk and overall natural resource rent rise, environmental footprint (EFP) tends to decrease. All of the variables in the regression model in this study had VIF values less than 3. It is the bench mark as an acceptable level. This implies that multicollinearity is negligible in this particular model. Furthermore, the regression model's mean VIF value of 1.618 is less than the critical value of 3, indicating that multicollinearity is not a serious issue.

4.3. Cross-Sectional Dependency

The results in Table 4 suggests that there is a considerable level of dependency or interaction between the observations in the panel dataset. The findings show that modifications or interruptions to one observation or unit will have an impact on the dataset's remaining observations or units. The probability values of 0.00 were found for every variable under investigation in the research, suggesting strong evidence of cross-sectional independence.

The cross-sectional dependency shown in these data highlights the interdependence or independence of the variables under investigation.

Table 4. Cross-section dependency tests.

Variable Name	CD-Test	Probability	Aver. Joint T	Mean P	Mean abs (*p*)
EFP	14.89	0.05	14	0.03	0.34
GG	105.91	0.00	14	0.04	0.24
FR	15.78	0.00	14	0.03	0.34
$TNRR$	3.09	0.05	14	0.05	0.43
TI	14.67	0.00	14	0.33	0.54
FI	54.56	0.00	14	0.17	0.45
HCD	72.34	0.00	14	0.21	0.67
URB	37.89	0.00	14	0.03	0.54
IND	0.98	0.00	14	0.2	0.78

By using ANCOVA or a similar method, the slope homogeneity is found in Table 5.

Table 5. Test of the slope for homogeneity.

Test	Value	*p*-Value
Δ	21.46 *	0.0000
Δ adjusted	29.31	0.0000

Note: The significance level of 1% is represented by the symbol *.

The test statistics for "and "adjusted" are, respectively, 21.46 * and 29.31 *. Extremely low *p*-values ("00") for both test findings show that they are highly significant, providing strong evidence against the null hypothesis, which states that the slopes of the groups and situations are the same. As a result, there are significant differences in the slopes across the circumstances or categories under comparison.

After estimating the results of the Cross IPS and Cross ADF tests in Table 6, it is suggested that our results are in favor of accepting the null hypothesis at the I(0) level since all panel variables are nonstationary.

Table 6. Unit root test for the panel.

	Pesaran's Cross ADF		Cross IPS Unit Root	
Variables	**I(0)**	**I(1)**	**I(0)**	**I(1)**
EFP	−1.23	3.21 **	1.45	3.56 ***
GG	−1.43	3.23 **	2.12 **	3.245 ***
FR	2.12	2.89 **	2.21	3.56 ***
$TNRR$	−3.12	3.23 **	1.67	3.87 ***
TI	−1.45	3.45 ***	1.83	3.78 **
FI	−1.22 **	3.23 ***	1.82 **	3.67 **
HCD	3.21	3.41 ***	1.46	3.89 **
URB	1.02	3.67 **	2.69	3.67 **
IND	2.81	3.45 **	1.95	3.68 **

, * shows the level of significance at 5% and 10% respectively.

When the variables are differentiated once, the alternative hypothesis of stationarity prevails over the null hypothesis of nonstationary (I(1)). As a result, when assessed at the initial difference, the variables continue to maintain a stable state, per the findings.

4.4. Pedroni Test for Cointegration

To determine if the variables have a long-term relationship, the Panel Cointegration test employed. The findings in Table 7 demonstrate the existence of cointegration.

Table 7. Pedroni test for cointegration.

	t-Stat	Prob.	Result
Modified Phillips Perron test	15.1323	0.0000	"Cointegration Exists"
Modified Phillips Perron test	−8.9241	0.0000	"Cointegration Exists"
Augmented Dickey–Fuller test	−8.7271	0.0000	"Cointegration Exists"

A t-statistic of 15.1323 was obtained using the Phillips–Perron test, with a significance level of 0.000. This points to a long-term link between the variables and strongly implies cointegration. Additionally supporting the existence of cointegration was the Phillips–Perron test, which had a t-stat of −7.7271 and a *p*-value of 0.000. The idea that the factors have a long-term link is supported by these findings. A Dickey–Fuller test with a *p*-value of 0.000 and a T statistic of −8.9241 showed cointegration. This implies that there is a long-term link between the variables and that they are not totally random.

4.5. Fully Modified Ordinary Least Squares

The extent to which regression model predictor variables account for the variation in the dependent variable is measured by the R-squared value (0.66464). About 55.27% of the variance in the dependent variable in this instance is explained by the independent factors. The number of independent variables is considered in the adjusted R-squared (0.570456), which deviates somewhat from the R^2. The dependent variable's long-run variance, which provides information on stability and volatility, is 0.035672. This indicates the variable's consistent variability across time.

Significant relationships between factors and environmental footprint (EFP) are shown by analysis that is presented in Table 8. A statistically significant link between variable FR and EFP is indicated by the coefficient of −0.05034. Although *p*-value = 0.0725 indicates a modest level of significance, greater FR values appear to be associated with lower EFP. In contrast, variable GG, with a coefficient of −6.09241, shows a statistically significant negative correlation. This points to a significant correlation between lower EFP and higher GG. With a *p*-value of 0.0264, this link is statistically significant at the 5% level, highlighting GG's strong impact on environmental footprint.

The research highlights important conclusions about the influence of factors on environmental footprint. The variable TI has a statistically significant negative connection (*p*-value of 0.002, coefficient of 0.04251), suggesting that reduced environmental impact is associated with greater TI values. In a similar vein, there is a significant inverse association between TNRR and EFP (coefficient: −0.2451, *p*-value: 0.0023), where higher TNRR is associated with lower EFP. On the other hand, FI shows a significant positive connection (*p*-value: 0.0003, coefficient: 0.03412), indicating that a larger environmental impact is associated with higher FI. These findings highlight how important FR, GG, TI, TNRR, and FI are in determining EFP.

Table 8. Fully modified OLS.

Variable EFP	Coefficients	Std. Error	t-Statistics	Prob.
GG	−6.09241	0.000613	−0.233327	0.0725
FR	−0.05034	4.149617	1.372562	0.0264
$TNRR$	−0.2451	0.012986	2.327769	0.0023
TI	0.04251	0.01415	−9.393242	0.002
FI	0.03412	0.016461	3.48564	0.0003
HCD	0.02994	0.004783	6.260303	0.00
URB	0.02994	0.004783	6.260303	
IND	0.02994	0.004783	6.260303	
R^2	0.66464	$\overline{X}$ dependent variable		11.33871
Adj. R^2	0.570456	Standard deviation dependent variable		1.632583
Standard error	0.10454	SSR		16.05428
Long run σ^2	0.035672			

4.6. Robustness Test

With an R-squared value of 0.56442, the independent variables in the regression model may account for around 56% of the variance seen in the dependent variable. The average quantity of EFP in the dataset is represented by the average in terms of the mean of the dependent variable, EFP, which is 11.29986. The volatility or dispersion of EFP around the mean is represented by the dependent variable's standard deviation, which is 1.631627.

The average difference between the values predicted by the regression model and the actual EFP is then represented by the standard error of the regression, or S.E. of regression, which is 0.20344. The total squared difference between the actual EFP and the predicted value by the model is 21.5628, which is the sum of squared residuals. Table 9 presents the results of the robustness test. Every dimension variable passed the significance test based on the test findings. This proves that the effects of FR, TNRR, GG, TI, and FI on environmental footprint are stable.

Table 9. Panel dynamic OLS.

Variable EFP	Coefficients	Standard Error	t-Statistics	Probability
GG	−3.9234	4.1537	0.944558	0.034
FR	0.000259	0.000589	0.439215	0.066
$TNRR$	−0.099539	0.012282	−8.10462	0.00
TI	0.023349	0.012661	1.844156	0.065
FI	0.071974	0.015072	4.775372	0.00
HCD	0.02994	0.004783	6.260303	0.00
URB	0.02994	0.004783	6.260303	
IND	0.02994	0.004783	6.260303	
R^2	0.56442	$\overline{X}$ dependent variable		11.33871
Adj. R^2	0.570456	Standard deviation dependent variable		1.632583
Standard error	0.20344	SSR		16.05428
Long run σ^2	0.035672			

4.7. Discussion

This study demonstrates that reducing financial risk and leaving less of an environmental impact are incompatible. Policymakers need to take steps to reverse the inverse link between risks and emissions and control financial risks in order to minimize environmental footprint without endangering economic development and national stability. Using renewable energy sources and accelerating technical innovation can help achieve both steady, orderly economic growth and less environmental impact. We have found a strong positive correlation between stable economies and carbon emissions. There is a strong inverse relationship between greenhouse gas emissions and financial development. In contrast, the environmental footprint of nations with greater populations and faster rates of urbanization is higher [61].

Tables 8 and 9 of this study attempts to determine the negative correlation between environmental footprint and financial risk. Financial risk eventually affects total natural resource rent, green growth, as well as technological innovation, all of which increase the environmental footprint. Financial risk has a minimum long-term coefficient, meaning that an increase in financial risk will promote an environmental footprint. There is a good correlation between long-term financial risk management and environmental footprint control. Nevertheless, the lengthy variance with other economic variables produces the best outcomes, indicating that managing environmental footprint and financial risk is not enough; in the long term, all three aspects will need to be controlled. With unparalleled growth in almost every industry, the world economy has grown at its quickest rate in the 20th century. However, this wealth has been accompanied by pollution. While industrial output has increased over the past three decades, the environment and the livelihoods of the locals have been in danger. The government is still working hard to clean up the environment and lessen environmental worries in addition to making sure the economy is stable for the long run.

Apart from guaranteeing enduring fiscal stability, the government persists in making substantial endeavors to purge the environment and lessen worries about the environment. The statistical results show that green growth and environmental impact are negatively correlated. According to [62] there is a 0.35 and 0.48% drop in environmental footprint at a 1% significance level for every 1% change in green growth and financial risk, respectively, over the short and medium terms. These findings align with the research. The coefficients of green growth are −5.695605 and −0.132910, respectively, demonstrating the effectiveness of global lobbying for a green economy and the cumulative effect of green growth on environmental footprint.

The global economy's green transformation and development have accelerated businesses' green technological innovation processes and quickened industrial optimization and upgrading. People's concerns about living better lives and consuming less energy have grown as the green movement has gained traction, leading to increased pollution. The present study's results align with those of the research conducted by [63] specifically, the identification of a negative association between greenhouse gas emissions and green growth expedites the development of green financing. A broad cultural change favoring sustainability has resulted from the local government's vigorous promotion and support of the green economy, and green concepts are now ingrained in all spheres of society. Over the long run, renewable energy has a 5% detrimental effect on EFP. This implies that carbon dioxide emissions are decreased by renewable energy. According to [64,65], there is a negative link between renewable energy and EFP. The former suggests that the latter enables the top 10 global greenhouse gas emitters to lower their carbon footprint.

According to another study, renewable energy has a negative coefficient, meaning that over time, it dramatically lowers consumption-based CO_2 emissions in BRI nations. Comparable outcomes are noted for renewable energy, suggesting that, in both short- and long-term models, renewable energy and EFP have a statistically significant and negative association. As per the aforementioned findings, renewable energy exhibits a negative coefficient and a noteworthy influence on greenhouse gases. Consequently, it is imperative for countries to augment their utilization of renewable energy in lieu of fossil fuels to foster sustainable development.

Both the FMOLS and DOLS models have a large coefficient for renewable energy, indicating a strong adverse effect on sustainable development. The findings of this study indicate that, at a level of 5%, financial inclusion significantly and positively impacts sustainable development. This outcome is in line with [66], which shows that financial inclusion (FI) improves EFP in the countries by 5% both in the short and long term. This implies that EFP rises in tandem with financial inclusion. In the countries under investigation, rising loan availability caused consumer spending on appliances like televisions, air conditioners, and refrigerators to soar. When these items are widely used, the amount of fossil fuels used to produce domestic energy is accelerated, which raises EFP. It also demonstrates how the nations allocate their financial resources to achieve their goals.

5. Conclusions and Policy Recommendations

Over the past 30 years, the concepts of environmental sustainability and environmental footprints have gained a great deal of traction and have assumed a central role in international forums. It is now a critical issue that calls for the development of a comprehensive framework for the economy and society that can successfully integrate social inclusion, environmental sustainability, and economic competitiveness. In order to tackle the significant issues brought about by human activity-induced global warming and environmental degradation, socially and environmentally acceptable financial practices must be implemented. The study finds that financial risk is one of the main determinants, along with technological innovation, natural resource rent, financial inclusion, and green growth in G7 countries.

Green growth is defined as enhancing economic development while guaranteeing the sustainable use of natural resources. This strategy aims to reduce environmental deterioration by integrating sustainable practices into economic activities. Financial risk is the possibility of suffering financial losses as a result of environmental aspects, such as natural disasters, climate change, or alterations to laws meant to preserve the environment. Firms are more inclined to implement sustainable practices when financial risk is high in order to minimize potential losses and lessen their environmental impact. On the other hand, minimal financial risk linked to environmental deterioration would encourage people to continue engaging in unsustainable behaviors, which would increase their environmental impact. Technology innovation is essential in lowering environmental footprints because it creates new instruments and processes that minimize resource consumption, cut waste, and decrease emissions. The environmental impact of human activity can be greatly reduced by technology, as demonstrated by advancements in sustainable agriculture, waste management, and renewable energy.

The environmental footprint is directly impacted by natural resource availability and management. Deforestation, mining, and the extraction of fossil fuels are examples of overexploitation of natural resources that cause serious environmental damage. The environmental footprint can be decreased by the sustainable management of natural resources, which includes the preservation of ecosystems and the development of renewable resources. Sustainable practices and innovation are encouraged by human capital development, which aims to enhance the workforce's health, education, and abilities. This has the potential to impact environmental footprints. A population with higher levels of education and ability is more likely to embrace eco-friendly habits and technology, reducing its environmental impact.

Recent studies have shown that financial inclusion is essential for advancing sustainable development and has a favorable effect on a number of factors. It has also been determined that improvements in technology can contribute to favorable results. The advantages of financial inclusion and technical advancement in the financial sector must be carefully weighed against the requirements of environmental preservation, EFP abatement, and a positive environmental impact.

Recommendations and Limitations

Prioritizing the adoption of green growth techniques in these countries is one of the main recommendations. By supporting investments in ecologically sustainable projects, renewable energy, and the use of cutting-edge eco-friendly technology to address environmental issues, governments may promote economic growth. This entails creating regulations that encourage financial institutions to support environmentally friendly initiatives and providing financial aid to entice individual investors in renewable energy sources. Nonetheless, this work provides directions for more investigation. It is important to recognize that, even while the selected countries offer insightful information, the effects of green financial metrics might vary greatly amongst them. To obtain more thorough findings, future researchers should repeat this study with a wider variety of nations.

Comparative studies between different locations, including developed and developing countries, may yield more insightful information. Furthermore, updating the study with more recent data might improve it. Notwithstanding these drawbacks, the thesis makes a substantial contribution to the body of knowledge already in existence and establishes the framework for further research in this area.

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